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Indian Standard

ENVIRONMENTAL TESTING PROCEDURES FOR MICROCIRCUITS

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MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

Gr 9

August 1983

Indian Standard

ENVIRONMENTAL TESTING PROCEDURES FOR MICROCIRCUITS

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Indian Standard

ENVIRONMENTAL TESTING PROCEDURES FOR MICROCIRCUITS

0. FOREWORD

0.1 This Indian Standard was adopted by the Indian Standards Institution on 24 December 1982, after the draft finalized by the Semiconductor Devices and Integrated Circuits Sectional Committee had been approved by the Electronics and Telecommunication Division Council.

0.2 This standard deals with the environmental requirements applicable to microcircuits. This standard shall be used in conjunction with relevant parts of IS : 9000* series.

0.3 The object of this standard is to establish uniform preferred test methods with preferred values for stress levels for judging the environmental properties of microcircuits.

0.4 The relevant detailed specifications shall specify the following:

a) The specific test to be carried out and the appropriate severities to be chosen from those covered in this standard;

b) The allowed performance limits during or after or during as well as after the environmental tests; and

c) Any deviation with regard to test procedures, final measurements; etc.

0.4.1 If there is any conflict between this standard and any detailed specifications, the provisions of the latter shall apply.

0.5 While preparing this standard, assistance has been derived from JSS 51400 (Part II) Test Methods for Microcircuits issued by the Directorate of Standardization, Ministry of Defence, Government of India.

1. SCOPE

1.1 This standard lays down the environmental requirements and the tests designed to assess the durability under various conditions of production, use, transport and storage of microcircuits used in electronic and other similar equipment.

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*Basic environmental testing procedures for electronic and electrical items.

2. TERMINOLOGY

2.0 For the purpose of this standard, the terms and definitions given in IS : 2016 (Part I)-1962* shall apply.

3. GENERAL CONDITIONS AND PRECAUTIONS

3.1 Standard Atmospheric Conditions

3.1.1 Unless otherwise specified, all tests and recoveries shall be carried out under the following standard atmospheric conditions for testing:

Temperature	15° C to 35° C
Relative humidity, where appropriate	45 to 75 percent
Air pressure	86 to 106 Pa

3.1.2 Unless specified otherwise all measurements shall, however, be carried out under the following conditions:

Temperature	25 ± 5°C
Relative humidity, where applicable	45 to 75 percent
Air pressure	86 to 106 Pa

3.1.3 Reference tests and measurements shall be carried out under the following standard atmospheric conditions:

Temperature	25 ± 1°C
Relative humidity	48 to 52 percent
Air pressure	86 to 106 Pa

3.2 Equilibrium Conditions — Unless otherwise specified, all electrical measurements shall be conducted under equilibrium conditions. When these conditions cause significant variation, with time, of the characteristic being measured, means of compensation for such effects will be specified in the individual standard, for example, the length of time that the device shall be maintained at the equilibrium conditions before making a measurement.

3.3 Permissible Temperature, Variation in Environmental Chambers — When chambers are used, specimens under test shall be located only within the working area defined as follows.

3.3.1 *Temperature Variation Within Working Area* — The controls for the chamber shall be capable of maintaining the temperature of the reference point within the working area within ± 2°C.

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*Environmental tests for electronic and electrical equipment : Part I General.

3.3.2 *Space Variation Within Working Area* — Chambers shall be so constructed that, at any given time, the temperature of any point within the working area shall not deviate by more than ± 3°C from the reference point, except for the immediate vicinity of specimens generating heat.

3.4 Recovery Conditions and Final Measurements — Final measurements, specified in individual specifications, shall be carried out for each device after completion of the specified tests. All applicable final measurements shall be carried out within 96 hours after the samples have been subjected to the required physical, mechanical or climatic tests.

3.5 Electrical Measurements Before, During or After Conditioning — The parameters to be checked before, during and after the environmental tests shall be specified in the individual specifications.

3.6 Precautions

3.6.1 For general precautions, reference may be made to IS : 5469 (Part I)-1969*. In addition, the provision of **3.6.2** to **3.6.6** shall also apply.

3.6.2 Overhauling of the devices shall be avoided while soldering the terminals of the specimen.

3.6.3 The specimen shall not be subjected to transients which cause the rating to be exceeded. It is recommended that the devices should not be inserted into or removed from circuit while it is energized.

3.6.4 In working with specially sensitive devices, it is advisable to make the earth connection of the soldering iron to the earthed framework being assembled, to avoid the risk of possible ' inter-earth ' transient voltage appearing between iron and the equipment.

3.6.5 Due precautions should be taken while testing the devices in strong fields of electric, magnetic, electromagnetic and nuclear radiations.

3.6.6 During measurements, the specimens shall not be exposed to draughts, illumination or other influences likely to cause error.

4. ORIENTATIONS

4.1 Wherever applicable, the device orientation axes shall be specified to enable application of the tests appropriately.

4.1.1 Reference to Fig. 1A may be made for orientation of non-cylindrical devices to the direction of accelerating force.

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*Code of practice for the use of semiconductor junction devices : Part I Applicable to all devices.

4.1.2 Reference to Fig. 1B may be made for orientation of cylindrical device to the direction of accelerating force.

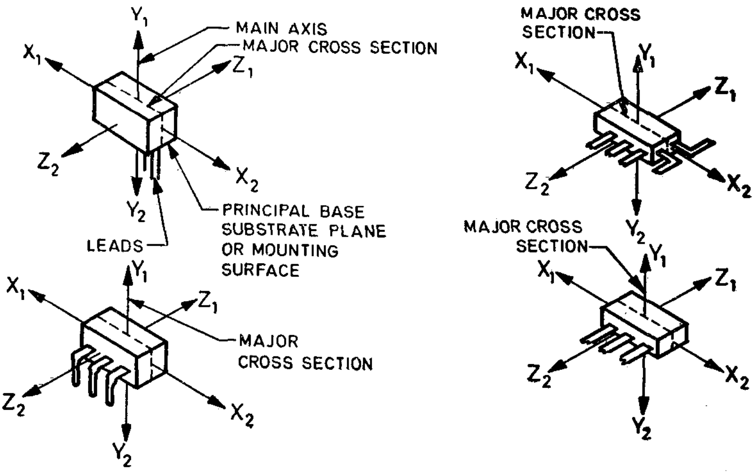
4.1.3 For case configurations, other than shown in Fig. 1A and 1B, the orientation of the device shall be as specified in the relevant individual specification.

4.2 In these two Fig. 1A and 1B:

a) *X* is the orientation of a device with the main axis of the device normal to the direction of accelerating force, and the major cross section parallel to the direction of accelerating force;

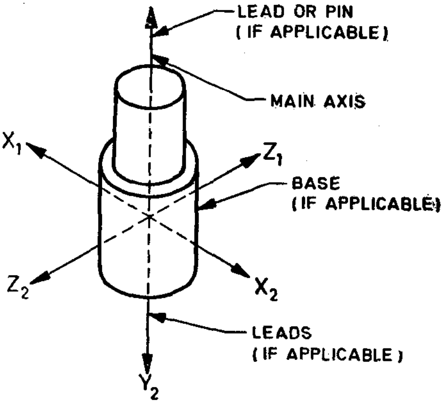
b) *Y* is the orientation of a device with the main axis of the device parallel to the direction of the accelerating force and the principal base towards (Y_1), or away from (Y_2), the point of application of the accelerating force; and

c) *Z* is the orientation of a device with the main axis and the major cross section of the device normal to the direction of the accelerating force.



NOTE — The application of force in the Y_1 direction shall tend to lift the die from the substrate or the wire from the die.

1A Orientations of Different Types of Microciruit Non-Cylindrical Packages to Direction of Applied Force



NOTE — The application of force in the Y_1 direction shall tend to lift the die from the substrate or the wires from the die.

1B Orientation of Cylindrical Microcircuit Package to Direction of Applied Force

FIG. 1 ORIENTATION OF DEVICES

5. ENVIRONMENTAL TESTS

5.1 The test schedule shall be in accordance with Table 1.

6. ACCELERATION (STEADY STATE) TEST

6.1 Purpose — The purpose of this test is to determine the effects of constant acceleration on the microcircuit. This test is an accelerated test designed to indicate types of structural and mechanical weaknesses not necessarily detected in shock and vibration tests.

6.2 Procedure

6.2.1 *Mounting of Components*

6.2.1.1 The components shall be secured to the centrifuge either directly or by means of a fixture as specified below.

6.2.1.2 Mounting fixtures shall be such as to subject the components to acceleration in each plane and sense as specified.

6.2.1.3 Components having a unique method of mounting shall be so mounted suitable protection shall be provided for component terminations.

TABLE 1 ENVIRONMENTAL TEST PROCEDURES FOR MICROCIRCUITS

(*Clause* 5.1)

SL No.	TITLE OF TEST	CLAUSE REFERENCE
(1)	(2)	(3)
1.	Constant acceleration	6
2.	Low air pressure	7
3.	Burn	8
4.	Salt mist	9
5.	Moisture resistance	10
6.	Dew point	11
7.	Flammability	12
8.	Impact or shock	13
9.	Immersion	14
10.	Resistance to soldering heat	15
11.	Resistance to solvents	16
12.	Robustness of terminations	17
13.	Sealing	18
14.	Solderability	19
15.	Rapid change of temperature	20
16.	Thermal characteristics	21
17.	Thermal shock	22
18.	Vibration	23

6.2.1.4 The mounting of components not provided with unique means of mounting shall be such that the test conditions applied should dynamically load the body or terminations or both. Either the body and the terminations, or the terminations only, may be clamped, as specified by the relevant component specification.

6.2.1.5 Components with axial terminations weighing less than 15 grams, shall be secured to rigid pillars leaving a distance of 5 to 8 mm between the point of emergence of the terminations and the pillars. Similar components weighing 15 grams and more shall be clamped so as to avoid any stress on the terminations.

6.2.1.6 Components with radial terminations and components having unusual mass distribution, shall be mounted as specified in the relevant component specification.

6.2.1.7 External connections made to the components for power supply and measurements shall add a minimum of mass and place a minimum of restraint on the components.

6.2.2 *Testing*

6.2.2.1 The relevant component specification shall specify the applicable acceleration severity.

6.2.2.2 The specified acceleration severity shall be applied to the components in both senses in each of the three mutually perpendicular planes, unless otherwise specified by the relevant component specification.

6.2.2.3 For 170 to 1 000 m/s^2 severities, the duration of the acceleration in each sense shall be 5 minutes, so that the components are accelerated for a total period of 30 minutes.

6.2.2.4 For 2 000 to 20 000 m/s^2 severities the duration of acceleration in each sense shall be as specified in the relevant component specification.

6.2.2.5 For 20 000 to 200 000 m/s^2 severities, the duration of the acceleration in each sense shall be 1 minute, so that the components are accelerated for a total period of 6 minutes. For these four severities, the rise and decay times of the acceleration shall, each be not less than 20 seconds.

6.2.2.6 The acceleration measured at any point on the component shall be within 15 percent of the specified value unless otherwise specified.

6.2.2.7 During the test, components shall be loaded or operated or loaded as well as operated and measured, if so specified by the relevant component specification.

6.3 Requirements — There shall be no evidence of mechanical damage to the device or any degradation in the operating characteristics.

6.3.1 The following details shall be specified in the relevant detailed specification:

a) The severity,

NOTE — The severities shall be any one of:

50 km/s^2, 100 km/s^2, 150 km/s^2, 200 km/s^2, 300 km/s^2, 500 km/s^2, 750 km/s^2, 1 000 km/s^2 and 1 250 km/s^2.

Unless otherwise specified, severity 200 km/s^2 shall apply;

b) Measurements to be made after test,

c) Any variations or limitations to orientation; and

d) Sequence of orientations, if other than as specified.

7. LOW AIR PRESSURE TEST

7.1 Purpose — The purpose of this test is to check the microcircuit capability under conditions simulating the low atmospheric pressure encountered in the non-pressurised portions of aircraft and other vehicles in high altitude flight. It is intended primarily to determine the ability of component parts and materials to avoid voltage breakdown failures due to the reduced dielectric strength of air and other insulating materials at reduced pressures. Even when low pressures do not produce complete electrical breakdown, corona and its undesirable effects, including losses and ionisation, are intensified.

7.2 Procedure

7.2.1 The components shall be placed in the chamber at the specified temperature if other than that specified for atmospheric conditions for testing and the air pressure within the chamber steadily reduced in 10 minutes or as specified in the relevant component specification to the appropriate severity. The specified air pressure (low) shall be maintained for the period specified.

7.2.2 While at the air pressure (low), the components shall be tested in accordance with the relevant component specification.

7.2.3 At the end of the test period, the air pressure in the chamber shall be returned steadily to normal using dry air, in 10 minutes or as specified in the relevant component specification. Care shall be taken that no condensation shall occur on the components during their return to laboratory temperature in the testing chamber.

Note — When this test is performed at low or high temperatures the chamber temperature shall be brought to the appropriate temperature severity before reducing the air pressure.

7.2.4 Twenty minutes before and during the test, the test temperature shall be 25°C ± 10°C. The device shall have the specified voltage applied and shall be monitored over the range from atmospheric pressure to the specified minimum pressure and return, for any device malfunctions. The terminals to which the maximum voltage is applied shall be monitored with a microammeter or oscilloscope for corona currents in the range from dc to 30 MHz. Provision shall be made for calibrating the current flow in the test circuit minus the device, under the applicable test conditions, to ensure that test readings are characteristic of the device under test.

7.2.5 The components shall be removed from the test chamber and allowed to remain under recovery conditions for a period of 1 hour or as specified by the relevant component specification.

7.3 Requirements — There shall be no arc-over, corona or any other defect or deterioration likely to interfere with the satisfactory operation of the device.

7.3.1 The following details shall be specified in the relevant detail specification:

a) Severity,

NOTE — The severities shall be any one of:

53 kPa, 30 kPa, 8·5 kPa, 4·4 kPa,
1 kPa, 0·15 kPa, and 6·10 kPa, $0{\cdot}32 \times 10^{-6}$ kPa
Unless otherwise specified, severity 1 kPa shall apply.

b) Method of mounting, and

c) Measurements to be made during the test. Unless otherwise specified, the device shall be subjected to the maximum voltage that it would experience under rated operating conditions.

8. BURN IN (SCREEN)

8.1 Purpose — The burn in (screen) is performed for the purpose of eliminating marginal devices, those with inherent defects or defects resulting from manufacturing aberrations which are evidenced as time and stress dependent failures.

8.2 Procedure — The apparatus required for the conducting this test shall consist of suitable chambers to maintain the devices at specified test temperature and provide access to specified electrical connections, and appropriate electrical test equipment to provide the required electrical inputs and perform the specified final measurements.

The microelectronic device shall be subjected to the burn-in screen at the temperature and for the time specified. The device shall be operated under the specified test condition. Lead, stud or case mounted devices shall be mounted by the leads, stud or case in their normal mounting configuration and the point of connection shall be maintained at a temperature not less than the specified temperature. Final measurements shall be made as specified.

8.3 Test Conditions — The microelectronic devices shall be subjected to the specified test condition as described below for the specified time and temperature and the required measurements shall be made at the specified end points.

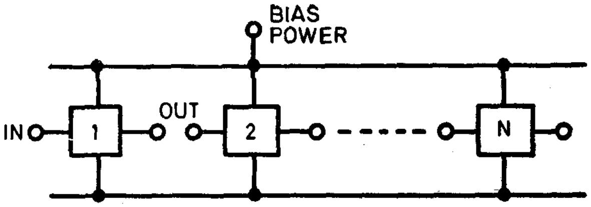
8.3.1 *Steady State Reverse Bias* — This test condition (*see* Fig. 2A) is suitable for use on all types of circuits, linear or digital types. In this test as many junctions as possible shall be reverse biased to the specified voltage and power dissipation. The ambient test temperature shall be the maximum possible but shall be selected so as not to exceed the thermal rating of the device.

8.3.2 *Steady State, Power* — This test condition (*see* Fig. 2A) may be used on all digital type circuits and on some linear types. In this test, as many junctions as possible shall be forward biased as specified. The ambient test temperature shall be the maximum possible but shall be selected so as not to exceed the thermal rating of the device.

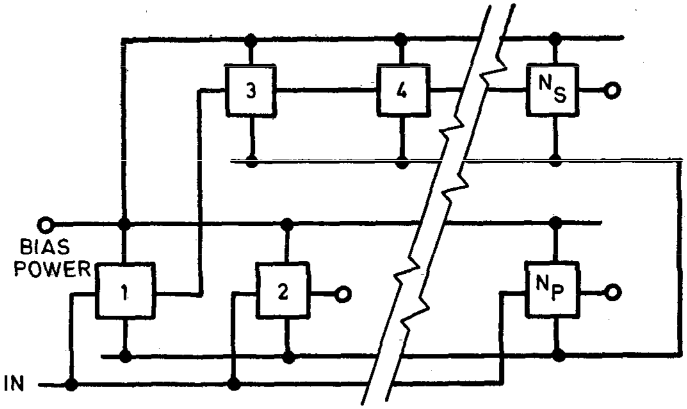
8.3.3 *Steady State, Power and Reverse Bias* — This test condition (*see* Fig. 2A) is used strictly on digital type circuits where the inputs may be reverse-biased and the output may be biased for maximum power dissipation or vice versa. The ambient temperature shall be selected so as not to exceed the maximum thermal rating of the device.

8.3.4 *Parallel Excitation* — This test condition (*see* Fig. 2B) is suitable for use on all circuit types. Each circuit is driven with an appropriate signal to simulate circuit application as closely as possible. All circuits shall have a maximum load applied, the excitation shall be applied at a frequency of not less than 50 Hz and the test shall be conducted at the maximum rated temperature unless otherwise specified. This test is usually referred to as parallel switching applied to digital circuit.

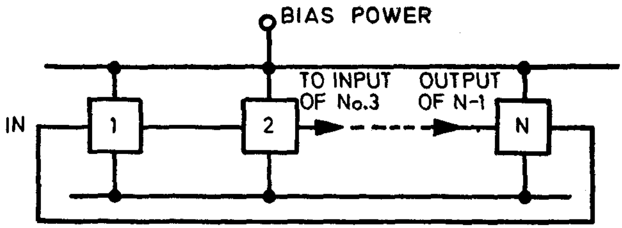
8.3.5 *Ring Oscillator* — In this test (*see* Fig. 2C), any number of digital circuits greater than two are connected in series. For circuits that cause phase inversion, an odd number of circuits should be used with the output of the last circuit connected to the input of the first circuit. The series will be free running at frequency established by the propagation delay of each circuit and its associated wiring. Each circuit in the ring shall be loaded to its rated maximum and biased at normal rated voltage. The test shall be conducted at maximum rated temperature unless otherwise specified. This test may be conducted with the open-ring or series switching configuration where the first device in the series is switched by an external source. In this configuration, the duty cycle and the basic frequency of operation depend mainly on the capabilities of the individual devices. When the free running or ‘ closed ’ ring configuration is employed, no more than 21 devices shall be contained in any single ring. Where the ‘ open ’ ring configuration is employed, the time duration between inputs from the external source shall be not greater than 20 times the propagation delay of the device as specified in the detail specification. While this test condition affords the opportunity to continuously monitor the test for catastrophic failure (that is ring stoppage), this shall not be considered acceptable as a substitute for intermediate measurements, when required.



2A Steady State



2B Parallel Excitation



2C Ring Oscillator

NOTE — For free running counter, *N* is an odd number and the output *N* is connected to the input of 1.

FIG. 2 CONDITIONS FOR BURN-IN

8.4 Information to be Given in Relevant Detail Specification

a) Test duration — unless otherwise specified the minimum test duration shall be 168 hours,

b) Test condition,

c) Final measurements, and

d) Requirements for inputs, outputs, biases and power dissipation as applicable.

9. SALT MIST TEST

9.1 Purpose — To determine the suitability of protective coatings (metallic and non-metallic) of components when subjected to conditions simulating the effects of sea coast atmosphere.

9.2 Procedure — Apparatus used in this test shall include the following:

a) Exposure chamber with racks for supporting devices;

b) Salt solution reservoir;

c) Means for atomising the salt solution, including suitable nozzles and compressed air supply;

d) Chamber heating means and controls; and

e) Means for humidifying the air at a temperature above the chamber temperature.

9.2.1 *Initial Conditioning* — Prior to mounting, specimens for the salt atmosphere shall be subjected to bending and torsion stresses. Each lead of each specimen shall be exposed to the following stresses :

a) Bending stress — (*See* **19**), and

b) Lead or terminal torque — (*See* **19**).

The device shall be placed within the test chamber. A salt atmosphere fog having a temperature of 35°C shall be passed through the chamber for the specified test duration, unless otherwise specified. The fog concentration and velocity shall be so adjusted that the rate of salt deposit in the test area is between 10 000 and 50 000 mgm/m^2/day. On completion of the test and to aid in the examinations, salt deposits shall be removed by a gentle wash or dip not warmer than 37·8°C and a light brushing using a soft hair brush or plastic bristle brushing.

9.3 Requirements — Marking shall be legible. There shall be no evidence of flaking or pitting of the finish, or corrosion that will interfere with the operation of the device.

Information to be given in the relevant detailed specification is as following:

a) Time of exposure — Unless otherwise specified, the time shall be 24 hours; and
b) Measurements and examinations after test.

10. MOISTURE RESISTANCE TEST

10.1 Purpose — The moisture resistance test is performed for the purpose of evaluating, in an accelerated manner, the resistance of the device to the deteriorating effects of the high humidity and heat conditions typical of tropical environments.

10.2 Procedure

10.2.1 *Initial Conditioning*

10.2.1.1 Unless otherwise specified, prior to mounting, the device leads shall be subjected to bending stresses, as in **19.5.**

10.2.1.2 Unless otherwise specified in the relevant component specification, the components shall be dried in the dry heat chamber at 50 ± 2°C for 24 hours.

10.2.1.3 The temperature of the components shall then be reduced to that specified for atmospheric conditions for testing or any other temperature specified by the relevant component specification and maintained at this temperature for such a period as to enable the components to attain temperature stability prior to carrying out the initial measurements as required by the relevant component specification.

10.2.2 *Testing*

10.2.2.1 The components shall then be introduced into the damp heat chamber maintained at 25 ± 2°C and relative humidity of 90 to 98 percent.

10.2.2.2 The temperature of the chamber shall then be gradually raised to 65° ± 2°C. This shall be achieved in a period of two and a half hours, the relative humidity being maintained between 90 and 98 percent throughout this period.

10.2.2.3 These temperature and relative humidity conditions shall be maintained for five and a half hours from the start of the cycle.

10.2.2.4 The temperature shall then be allowed to fall to 25 ± 2°C within a period of two and a half hours, the relative humidity being maintained between 80 and 98 percent.

10.2.2.5 The sequence of operations described in **10.2.2.2** to **10.2.2.4** shall then be repeated.

10.2.2.6 The relative humidity shall then be raised to a level of 90 to 98 percent and the temperature maintained at 25° ± 2°C for a period of 8 hours. This completes one cycle of the test. An additional sub-cycle as stated in **10.2.2.7** and **10.2.2.8** shall be performed during any five of the first nine cycles during this eight hour period.

10.2.2.7 At least 1 hour but not more than 2 hours after the beginning of the conditions stated in **10.2.2.6**, the components shall be subjected to one of the following conditions:

a) Exposure to cold in the same chamber

   i) The components shall be exposed to cold by lowering the temperature of the chamber. Beginning between 17 and 18 hours after the start of the cycle the temperature of the chamber shall be allowed to fall to —10 ± 2°C. This temperature shall be reached at eighteen and a half hours after the start of the cycle.

   ii) Beginning at eighteen and a half hours after the start of the cycle the temperature shall be raised to 25 ± 2°C for a period of three hours.

   iii) Beginning at twenty one and a half hours after the start of the cycle the temperature shall be raised to 25 ± 2°C in a period of between half and one and a half hours.

b) Exposure to cold in a separate chamber

   i) The components shall be transferred from the humidity chamber to the cold chamber with a period of five minutes.

   ii) The components shall then be exposed to a temperature of —10 ± 2°C for a period of three hours.

10.2.2.8 Within 15 minutes after completion of the conditions stated in **10.2.2.7**, the components shall be vibrated in the frequency range of 10 to 55 Hz for 15 minutes, at atmospheric conditions for testing, using simple harmonic motion, having an amplitude of 0·75 mm (1·5 mm total excursion). The entire frequency range from 10 to 55 Hz and return to 10 Hz shall be traversed in approximately 1 minute. The components shall then be maintained at 25 ± 2°C and 90 to 98 percent relative humidity for the remaining period of the cycle.

10.2.2.9 If specified by the relevant component specification, the components shall be electrically loaded during the exposure to humidity conditions.

10.2.2.10 The components shall be subjected to 10 continuous cycles.

10.2.2.11 On completion of the conditions stated in **10.2.2.4** of the final cycle, when measurements at high relative humidity are specified by the relevant component specification, the components shall be maintained at 25 ± 2°C with 90 to 98 percent relative humidity for a period of one and a half to three and a half hours, after which the specified measurements shall be made. Due to difficulty in making measurements under high relative humidity conditions, the relevant component specification shall specify the necessary precautions to be observed while making such measurements.

10.2.2.12 During the moisture resistance test, when specified, the device shall be biased in accordance with the specified bias configuration which should be chosen to maximize the voltage differential between chip metallizations or external terminals, minimize power dissipation and to utilise as many terminals as possible, to enhance the test results.

10.2.3 *Recovery*

10.2.3.1 The component shall then be removed from the chamber. After removal from the chamber, surface condensation shall be removed from the component by shaking or as specified by the relevant component specification.

10.2.3.2 The components shall then remain under recovery conditions for a period of 24 hours or as specified by the relevant component specification.

10.3 Requirements — The devices shall satisfy the requirements of the measurements made after the test, as specified in the relevant detailed specification.

10.3.1 The following details shall be specified in the relevant detailed specification:

a) Initial measurements and conditions, if other than room ambient;
b) Applied voltage (when applicable);
c) Measurements at high humidity, when applicable and precautions as applicable; and
d) Final measurements.

11. DEW POINT

11.1 Purpose — To detect the presence of moisture trapped inside the device package in sufficient quantity to adversely affect device parameters.

11.2 Procedure — The apparatus used in this test shall be capable of varying the temperature from the specified high temperatures to —65°C while the parameter is being measured. The voltage and current specified shall be applied to the terminals and the device leakage current continuously monitored from the specified high temperature to −65°C and back to the high temperature. The dew point temperature is indicated by a sharp discontinuity in the parameter being measured with respect to temperature. If a high temperature is not specified in the relevant detail specification, the device shall be taken to a temperature at least 10°C above ambient temperature to initiate this test saturation. The rate of charge of temperature for this test shall be not greater than 10°C per minute. The test voltage shall be at least equal to the rated breakdown voltage of the device since it is necessary to apply sufficient voltage to achieve ionization.

11.3 Requirements — There shall be no discontinuity or instability of the measured parameter with respect to temperature, at any point during the test.

Information to be given in the relevant detail specification is as following:

a) Test temperature, high and low if other than —65°C;

b) Test voltage and current; and

c) Test parameter.

12. FLAMMABILITY

12.1 Internal

12.1.1 *Purpose* — To determine whether the device ignites due to internal heating caused by excessive overload.

12.1.2 *Procedure* — The device shall be operated in free air without a heat sink and the internal electrical power dissipation slowly increased from the maximum rated value until any of the following occurs:

a) An internal power dissipation equal to five times the maximum rated power dissipation at 25°C is reached; in this case, the power shall be maintained for a minimum duration of one minute; or

b) The device becomes either open or short circuited or its resistance increases to such a high value that any further increase in power dissipation is impracticable.

12.1.3 *Requirements* — The device shall not ignite or omit flammable vapours.

12.2 External

12.2.1 *General* — The device shall be tested in accordance with the test given below. The device shall be exposed the flame until it ignites or for 15 seconds, whichever is shorter. If ignition of the device has occurred any visible flame shall disappear within 10 seconds of withdrawal from the burner flame.

12.2.2 *Purpose* — To determine whether components will support combustion.

12.2.3 *Test Chamber* — The chamber shall consist of an enclosure protected from air currents, but provided with means of venting fumes and admitting an adequate supply of fresh air at the bottom.

NOTE — A metal box about 60 cm wide, 90 cm high and 60 cm deep, with a detachable front, a viewing window and suitable holes for intake of air and venting of fumes may be used.

The chamber shall be substantially draught free.

NOTE — Adequate safety precautions shall be taken to protect personnel from possible explosion of the components.

A suitable stand or support for the components involving a minimum of heat transfer shall be used inside the chamber.

A spirit burner of the pattern shown in Fig. 3A shall be used. The fuel for the burner shall be good quality 66° P industrial methylated spirit containing 5 percent of wood naptha. The burner and the flame are considered satisfactory if a bare copper wire 0·71 mm dia having a free length of not less than 100 mm in the flame in the position to be occupied by the components, melts in less than 6 seconds.

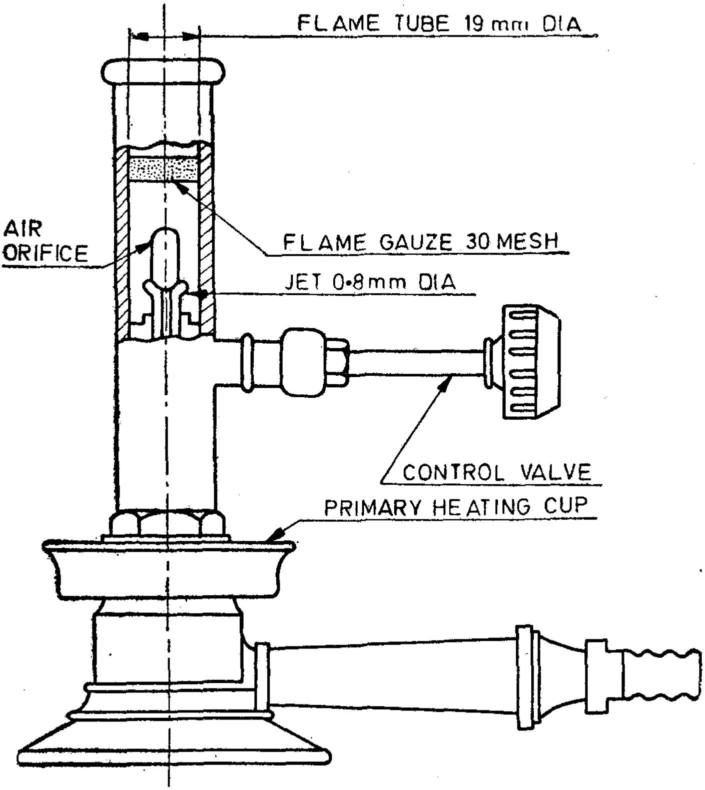
NOTE — The melting point of copper is 1 083°C.

12.2.4 *Procedure for Mounting of Components* — The components shall be mounted on the stand placed within the test chamber so that they are not shielded from the flame by the support. The precise orientation of the components relative to the flame, if not stated in the relevant component specification, shall be that judged to be the most unfavourable or which presents maximum surface to the test flame. The height of the components shall be so adjusted that the lowest part of the body of the component is 51 ± 1 mm from the top of the burner as shown in Fig. 3B.

12.2.5 *Testing* — After confirming that the flame is satisfactory as specified in the last paragraph of **12.2.3**, the burner shall be placed underneath the components in such a manner that they are enveloped by the flame. The components shall be exposed to the flame for one minute before the flame is withdrawn.

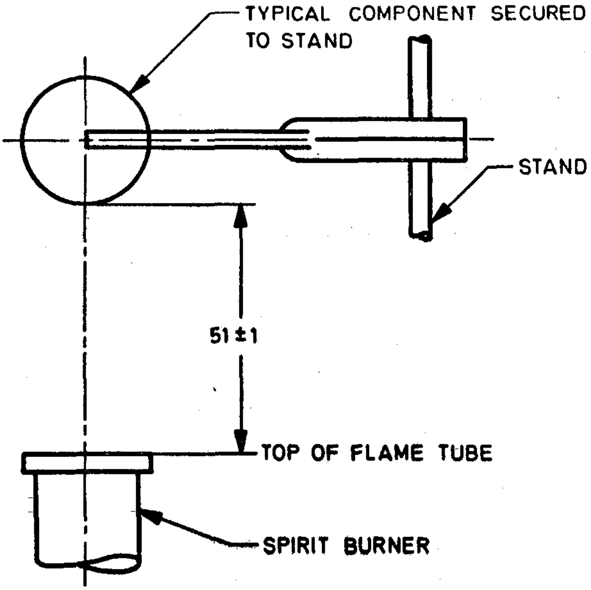
If ignition of the components has occured, it shall not continue for more than 15 seconds or any other period specified in the relevant component specification, after withdrawal of the flame.

The components shall be deemed to have failed if burning particles become detached from them.



3A Spirit Burner

FIG. 3 FLAMMABILITY TEST — *Contd*



3B Relative Position of Burner and Component

FIG. 3 FLAMMABILITY TEST

12.2.6 *Information to be Given in Relevant Detailed Specification*

- a) Proconditioning, if any;
- b) Initial measurements, if any;
- c) Specific mounting (orientation) instructions (*see* **4**);
- d) Permissible period of burning after withdrawal of flame if other than 15 seconds (*see* **12.2.5**);
- e) Final measurements, if any;
- f) Acceptable performance limits, if other than those specified in **12.2.5**; and
- g) Any deviation from the normal test procedure.

13. IMPACT (SHOCK)

13.1 Purpose — The purpose of this test is to determine the suitability of the devices for use in electronic equipment which may be subjected to moderately severe shocks as a result of suddenly applied forces or abrupt changes in motion produced by rough handling, transportation or field operation.

13.2 Procedure — The shock testing apparatus shall be capable of providing shock pulses of 5 km/s² to 300 km/s² (peak) as required with a pulse duration between 0·1 and 1·0 ms to the body of the device. The shock testing apparatus shall be mounted on a sturdy laboratory table or equivalent base and levelled before use. The device shall be rigidly mounted or restrained by its case with suitable protection for the leads. Means may be provided to prevent the shock from being repeated due to bounce in the apparatus. Unless otherwise specified, the device shall be subjected to 5 shock pulses of peak level specified in the selected test condition and for a pulse duration of between 0·1 and 1·0 ms in each of the orientations X1, X2, Y1, Y2, Z1 and Z2. Specified measurements shall be conducted after test and during test, where applicable.

13.3 Requirements — The following details shall be specified in the relevant detailed specification:

a) The severity,

NOTE — The severities shall be any one of the following:

5 km/s² (1 ms), 15 km/s² (0·5 ms), 30 km/s² (0·3 ms), 50 km/s² (0·3 ms),

100 km/s² (0·2 ms), 200 km/s² (0·2 ms) and 300 km/s² (0·12 ms).

Unless otherwise specified, severity 15 km/s² (0·5 ms) shall apply.

b) Measurements during test, if applicable.

14. IMMERSION

14.1 Purpose — This test is performed to determine the effectiveness of the seal of microelectronic devices. The immersion of the device under evaluation into liquid at widely different temperatures, subjects it to thermal and mechanical stresses which will readily detect a defective terminal assembly or a partially closed seam or moulded enclosure. Defects of these types can result from faulty construction or from mechanical damage such as might be produced during physical or environmental tests. The immersion test is generally performed immediately following such tests because it will tend to aggravate any incipient defects in seals, seams and bushings which might otherwise escape notice.

14.2 Procedure

14.2.1 The components shall be subjected to successive cycles of immersion, each cycle consisting of immersion in a hot bath of tap water at a temperature of 65^{+5}_{-0}°C, followed by an immersion in a cold bath. The number of cycles, the duration of each immersion and the nature and temperature of cold bath shall be as indicated below:

Severity	*Number of Cycles*	*Duration of Each Immersion Min*	*Nature of Cold Bath*	*Temperature of Cold Bath °C*
1	2	15	Tap water	25^{+10}_{-5}
2	2	15	Saturated solution of sodium chloride and water	25^{+10}_{-5}
3	5	60	Saturated solution of sodium chloride and water	0 ± 3
4	5	60	(Parts by volume) Water 48 part by volume Methanol 50 part by volume Morpholine 1 part by volume 3·5-dimethyl-1-hexyn-3-01 1 part by volume Stannous chloride 5 grams	0 ± 3

14.2.2 The transfer of the components from one bath to the other shall be accomplished as rapidly as practicable and shall not exceed 15 seconds in any case.

NOTE — When electrical measurements are made after immersion cycling to obtain evidence of leakage, the use of salt solution instead of tap water will facilitate detection of water penetration.

14.2.3 *Recovery*

14.2.3.1 The components shall be thoroughly and quickly rinsed in tap water.

14.2.3.2 The components shall be thoroughly dried externally by wiping or by applying a blast of air at atmospheric conditions for testing as required by the relevant component specification.

14.2.3.3 The component shall then remain under recovery conditions for at least four hours, but not more than 48 hours after completion of the final cycle.

14.3 Requirements — The following details shall be specified in the relevant detail specification:

a) Test severity;

NOTE — Unless otherwise specified, severity 3 shall apply.

b) Recovery time, if other than that specified;

c) Measurements after final cycle; and

NOTE — Unless otherwise specified, measurements shall include pin-to-pin resistance, pin-to-case resistance and full electrical test of all device characteristics or parameters listed in the applicable detailed specification. Final evaluation shall include external visual examination for legibility of device markings and for evidence of corrosion of package and leads, and

d) When specified, dissection and internal examination shall apply.

15. RESISTANCE TO SOLDERING HEAT

15.1 Purpose — The purpose of this test is to determine the ability of the device to withstand the heating effect associated with soldering.

15.2 Procedure

15.2.1 The wire terminations of components shall be immersed in such a manner as to leave a clearance of 6 mm from the point where the terminations emerge from the body or cap of the component.

15.2.2 The tag terminations of components shall be immersed to a depth of 3 mm beyond the place intended for the connection of wires referred to the free end or one half of the tag length, whichever is less.

15.2.3 The terminations shall be immersed for a period of 5 to 10 seconds in the flux which is maintained between 15°C and 35°C.

15.2.4 The fluxed terminations shall then be mechanically immersed at a rate of 20 to 30 mm per second into the solder bath, which has just previously been skimmed of dross and burnt flux. The solder bath shall be maintained between 340 and 360°C.

15.2.5 The terminations shall be allowed to remain in the solder bath for 3 to 3 5 seconds at the end of which period, they shall be withdrawn mechanically from the solder bath at a rate of 20 to 30 mm per second.

15.2.6 There shall be no evidence of damage due to heating on the surface of the components when examined under 10 power magnification.

15.2.7 If required heat sinks or shielding shall be made part of the test, and shall be as specified in the relevant component specification, including all of the details, such as materials, dimensions, method of attachment, and location of the necessary protection.

15.2.8 *Recovery* — The component shall remain under recovery conditions for a period of at least four hours.

15.3 Requirements — The following details shall be specified in the relevant detailed specification:

a) Pre-conditioning, if any;

b) Tests to be carried out prior to conditioning if applicable; and

c) Final measurements.

16. RESISTANCE TO SOLVENTS

16.1 Purpose — The purpose of the test is to check whether the device will withstand solvent which are commonly encountered during assembly operations and use.

16.2 Procedure

16.2.1 The components subjected to this test shall be divided into 3 equal lots. Each lot shall be individually subjected to solvent action as specified below:

a) The first lot shall be subjected to the solvent solution of one part of isopropyl alcohol and three parts of universal spirits by volume;

b) The second lot shall be subjected to trichloroethane; and

c) The third lot shall be subjected to azeotrope or trichloro-trifluoroethane (freon) and methylene chloride.

16.2.2 The solvent solution shall be maintained at a temperature of 25 ± 5°C. The component shall be completely immersed for one minute in the solvent solution.

16.2.3 Immediately following immersion, the component shall be brushed with normal hand pressure for 10 strokes on the portion of the component as specified in the relevant component specification using the brush of nonreactive material. The brush stroke shall be directed in a forward direction across the surface of the component under test.

16.2.4 Immediately after brushing, the above procedure shall be repeated two more times leading to a total of three immersions followed by brushing each time.

16.2.5 After five minutes, the component shall be examined to determine the extent, if any, of deterioration incurred.

16.2.6 *Plastic encapsulated Microcircuit Devices* — The sample to be tested shall be subdivided into three equal sub-samples. The resistance to each of the following three solutions shall be checked by immersing one sub-sample in each solution at a temperature of 25 ± 5°C for a minimum period of one hour:

a) Trichloroethylene;
b) Acetone; and
c) Methyl alcohol.

After removal from the solution, the devices shall be shaken to remove surplus liquid and then shall remain under normal atmospheric conditions for recovery for one hour before submission to the following tests:

a) Major dimensions; and
b) Change in weight.

16.3 Requirements

a) *Major Dimensions* — The change in major dimensions of the device before and after immersion in a solvent shall be as specified;
b) *Change in Weight* — The change in weight of a device before and after immersion in a solvent shall be not greater than 1 percent; and
c) The marking shall be permanent and legible.

17. ROBUSTNESS OF TERMINATIONS

17.1 Test A—Tensile

17.1.1 *Purpose* — The purpose of this test is to check the capabilities of the device leads, welds and seals to withstand a straight pull.

17.1.2 *Procedure* — The tension test requires suitable clamps, and hand vice for securing the specified weight 2·22 N unless otherwise specified to the device lead without lead restriction. The specified weight shall be applied, without shock, to each lead or terminal. When testing axial lead devices, the devices shall be supported, with the leads in a vertical position, by securing one lead to a clamp or vice. With a hand vice or equivalent, the specified weight, including the attaching device, shall be fastened to the lower lead for the time specified. Each lead shall be fastened as close to its end as practicable.

17.1.3 *Requirements* — When examined using 10X magnification after removal of the stress, there shall be no evidence of breakage, loosening or relative motion between the terminal and the device body.

17.1.3.1 The following details shall be specified in the relevant detailed specification:

a) Weight to be attached to lead; if other than 2·22 N;

b) Duration for which the weight is to be attached, if other than 30 seconds minimum; and

c) Measurements to be made after the test.

17.2 Test B—Lead or Terminal Torque

17.2.1 *Purpose* — The purpose of this test is to check device leads and seals for their resistance to twisting motion.

17.2.2 *Procedure* — The torque test requires suitable clamps and fixtures, and a torsion wrench or other suitable method of applying the specified torque without lead restriction.

17.2.2.1 *Devices with rectangular cross section terminals or leads* — The device body shall be securely held and the specified torque of 1412 mNm, unless otherwise specified, shall be applied to the terminal or lead at a distance of 3·05 ± 0·76 mm, from the device body or at the end of the terminal or lead if it is shorter than 3·05 mm. The torque shall be applied once each in the clockwise and anticlockwise direction. When devices have terminals or leads which are formed close to the body, torque may be applied 3·05 ± 0·76 mm away from the body. For device terminals or leads which twist noticeably where less than the specified torque is applied, the twist shall be continued until the twist angle reaches 30 ± 10 degrees or the specified torque is reached, whichever condition occurs first. The terminal or lead shall then be restored to its original position.

17.2.3 *Requirements* — When examined using magnification between 10X and 20X after removal of stress there shall be no evidence of breakage, loosening or relative motion between the terminal lead and the device body.

17.2.3.1 The following details shall be specified in the relevant detailed specification:

a) The magnitude of torque to be applied, if other than that specified;

b) No. of twist cycles, if more than 1;

c) The angle of twist, if other than 30; and

d) Measurements to be made after the test.

17.3 Test C—Stud Torque

17.3.1 *Purpose* — The purpose of this test is to check the resistance of the device with threaded mounting stud to the stress caused by tightening the device when mounting.

17.3.2 *Procedure* — The torque test requires suitable clamps and fixtures, and a torsion wrench or suitable method of applying the specified torque. The device shall be clamped by its body or flange. A flat steel washer of minimum thickness equal to six thread pitches and a new Class 2 fit steel nut shall be assembled in that order on the stud with all parts clean and dry. The specified torque shall be applied for the specified time without shock to the nut. The nut and washer shall then be disassembled from the device and the device examined for compliance with the requirements.

17.3.3 *Requirements* — The stud shall not break or exhibit elongation greater than half of one thread pitch. There shall be no visual or mechanical deformation such as stripping of threads, deformation of mounting seat and bending of stud.

17.3.3.1 The following details shall be specified in the relevant detailed specification:

a) The amount of torque to be applied;

b) Duration for which the torque is to be applied; and

c) Measurements to be made after test.

17.4 Test D—Lead Fatigue

17.4.1 *Purpose* — The purpose of this test is to check the resistance of the device leads to metal fatigue.

17.4.2 *Procedure* — The lead fatigue test requires suitable attaching devices, clamps, supports or other suitable hardware required to apply a repeated bending stress through the specified bend angle.

17.4.2.1 *Dual-in-line packages* — The device lead shall be subjected to three cycles of Test E (*see* **17.5**).

17.4.2.2 *Flat packages and can packages* — A force of 2 2 ± 0·15 N, unless otherwise specified, shall be applied to each lead to be tested for three 90 ± 5 degrees are of the case. For leads with a section modulus equal to or less than that of a lead with a cross section of 0·16 × 0·51 mm, the force shall be 0·83 ± 0·83 N. An arc is defined as the movement of the case without torsion to a position perpendicular to the pull axis and return to normal. All arcs on a single lead shall be made in the same direction and in the same plane without lead restriction. A bending cycle shall be completed within 5 seconds. For devices with rectangular or ribbon leads, the plane of the arcs shall be perpendicular to the flat plane on the lead. The test shall not be applied to the end leads of packages where its application will apply primarily torsion forces at the lead seal.

17.5 Test E Bending Stress

17.5.1 *Purpose* — The purpose of this test is to check the quality of the leads, lead welds and seals of the devices.

17.5.2 *Procedure* — Bending stress tests shall be made using attaching devices, clamps, supports or other suitable hardware required to apply the bending stress through the specified bending angle. Each lead of the devices shall be subjected to a force sufficient to bend the lead as specified in the succeeding paragraphs. Any number or all of the leads of the device may be bent simultaneously; rows of leads may be bent one row at a time. One cycle shall consist of one bend through the specified arc in one direction and return to the original direction; all the arcs shall be made in the same plane without lead restriction. The bends shall normally be in the least rigid direction.

17.5.2.1 *Devices with flexible leads* — A flexible lead is one whose section modulus (in the least rigid direction) is less than or equal to that of a rectangular lead with a cross section of 0·15 × 0·51 mm; round leads with diameter less than or equal to 0·51 mm shall be considered flexible. Flexible leads shall be bent through an angle of 45°C at a distance of 3·05 ± 0·76 mm along the lead from the seal unless otherwise specified.

17.5.2.2 *Devices with semi-flexible leads* — A semi-flexible lead is one with a section modulus (in the least rigid direction) greater than that of a rectangular lead with a cross section of 0·15 × 0·51 mm; round leads with diameter greater than 0·51 mm shall be considered semi-flexible· Semi-flexible leads shall be bent through an angle of 30 degree unless otherwise specified.

17.5.2.3 *Dual-in-line package leads* — A dual-in-line package lead has more than one section modulus, with leads normally aligned in parallel to a 90 degree angle from the bottom of the package during insertion. Dual-in-line package leads shall be bent through an angle sufficient to cause the lead to retain a permanent bend of at least 15 degree. At the completion of the bend, the leads shall be returned to their original position.

17.5.2.4 *Device with rigid leads* — A lead shall be considered rigid if it is not intended to be flexed during mounting and is not covered in the above paragraphs. Rigid leads shall be subjected to a normal mounting operation and removal unless otherwise specified.

17.5.3 *Requirements* — When examined using magnification between 10X and 20X after removal of the stress, there shall be no evidence of breakage, loosening, or relative motion between the lead and the device body.

17.5.3.1 The following details shall be specified in the relevant detailed specification:

a) Special preparations or conditions, if required;

b) Weight to be attached to lead;

c) Test method;

d) Duration for which the weight is applied; and

e) Measurements to be made after the test.

18. SEALING

18.1 Purpose — The purpose of this test is to determine the effectiveness of the seal of micro-circuit device which has an internal cavity, either evacuated or containing air or gas.

18.2 Procedure

18.2.1 The following definitions shall apply for the purpose of this test.

18.2.1.1 *Calculated leak rate* — The calculated leak rate is defined as that quantity of dry air at 25°C in pascals cubic decimeters flowing through a leak per second when the high pressure side is at 100 kPa and the low pressure side is at a pressure not greater than 133 Pa absolute. True leak rate shall be expressed in units of pascals cubic decimeters per second (Pa dm^3/s).

18.2.1.2 *Measured leak rate* — The measured leak rate is defined as the leak rate of a device as measured under specified conditions and employing a specified test fluid. Measured leak rate shall be expressed in units of pascals cubic decimeters per second (Pa dm^3/s). For the purpose of comparison, measured leak rates must be converted to calculated leak rates by employing the appropriate formulae.

18.2.2 *Fine Leak Detection*

18.2.2.1 The components in their completed state shall be placed in a sealed chamber, which is then pressurised with a tracer gas for the length of time prescribed for the equipment.

18.2.2.2 The pressure shall then be relieved. The components shall then be transferred preferably to another chamber which is connected to the evacuating system and the mass spectrometer type leak detector.

18.2.2.3 The leakage rate shall then be observed.

18.2.2.4 The component shall be checked for gross leak by a procedure specified by the relevant component specification.

NOTE — This procedure shall not be applied to components coated with organic materials. Further, in order to avoid spurious indications, contaminants or surface coatings that may conceal existing leaks, and which may absorb tracer gas on the surface of the component, shall be removed.

18.2.2.5 The measured leak rate (R) shall be converted to a calculated leak rate (L) at the specific test conditions — the minimum exposure pressure (P_E), minimum time of exposure (t_1) to P_E and maximum dwell time (t_2) between release of pressure and leak detection and shall be determined from the following formula by inserting the value of the internal volume of the device package.

$$R = \alpha \{ 1 - e^{-\beta} \} e^{-\gamma}$$

where

$$\alpha = \frac{LP_E}{P_0} \left(\frac{M_A}{M} \right)^{\frac{1}{2}}$$

$$\beta = \frac{Lt_1}{VP_0} \left(\frac{M_A}{M} \right)^{\frac{1}{2}}$$

$$\gamma = \frac{Lt_2}{VP_0} \left(\frac{M_A}{M} \right)^{\frac{1}{2}}$$

where

R = The measured leak rate of tracer gas through the leak in Pa dm³/s;

L = The calculated leak rate in Pa dm³/s;

P_E = The pressure of exposure in pascals;

P_0 = The atmospheric pressure in pascals;

M_A = The molecular weight of air;

M = The molecular weight of the tracer gas;

t_1 = The time of exposure to P_E in seconds;

t_2 = The dwell time between release of pressure and leak detection, in seconds; and

V = The internal volume of the device package cavity in dm³.

Unless otherwise specified, P_E shall be 500 kPa, t_1 shall be 1 hour minimum, and t_2 shall be a maximum of 30 minutes.

Unless otherwise specified, devices with an internal cavity volume of 0·1 cm³ or less shall be rejected if the measured leak rate exceeds 5×10^{-6} Pa dm³/s or the calculated leak rate under the conditions of test exceeds 5×10^{-5} Pa dm³/s and devices with an internal cavity volume between 0·1 cm³ and 10 cm³ shall be rejected if the measured leak rate exceeds 5×10^{-5} Pa dm³/s or the calculated leak rate under conditions of test exceeds 5×10^{-4} Pa dm³/s.

18.2.3 *Gross Leak Detection*

18.2.3.1 The devices shall be immersed in the container of the solution at 100°C to a minimum depth of 10 cm for one minute with their seals uppermost.

18.2.3.2 The devices having seals on more than one face shall be tested with each face in the uppermost position.

$$R = \alpha \left\{ 1 - e^{-B} \right\} e^{-\gamma}$$

where

$$\alpha = \frac{LP_E}{P_0} \left(\frac{M_A}{M} \right)^{\frac{1}{2}}$$

$$\beta = \frac{Lt_1}{VP_0} \left(\frac{M_A}{M} \right)^{\frac{1}{2}} \text{ and } \gamma = \frac{Lt_2}{VP_0} \left(\frac{M_A}{M} \right)^{\frac{1}{2}}$$

18.2.3.3 The container shall have flat sides to minimise reflections and distortions.

18.2.3.4 Solution : Non-corrosive ethylene glycol. The solution shall be of sufficient volume to be maintained at not less than 90°C for the entire duration of the test.

The devices shall be immersed in the container of the solution at 100°C to a minimum depth of 10 cm. Side lighting shall be used to facilitate viewing of the bubbles. There shall be no continuous stream of bubbles or a succession of bubbles originating from the device.

18.2.3.5 There shall be no leakage as determined by repetitive bubbles emerging from the components.

18.2.4 Other procedures are under consideration.

18.2.5 Precautions — This test shall be conducted under a ventilation hood due to toxic effects of ethylene glycol. This test shall not be used on microcircuits which have an internal free volume of 16·38 mm^3 or less.

18.3 Requirements — The following details shall be specified in the relevant detailed specification:

a) Applicable test method; and

b) Measurements to be made after the test.

19. SOLDERABILITY

19.1 Purpose — The purpose of this test is to determine the solderability of the wire leads which are normally joined by a soft solder.

19.2 Procedure

19.2.0 The test procedure and solder and flux used for the test shall be in accordance with IS : 9000 (Part XVIII/Sec 1)-1981*.

19.2.1 The terminations shall be immersed for a period of 5 to 10 seconds in the flux which is maintained between 15°C and 35°C.

19.2.2 The wire terminations of components shall be immersed in such a manner as to leave a clearance of 6 mm from the point where the termination emerges from the body or cap of the component.

19.2.3 The tag terminations of components shall be immersed to a depth of 3 mm beyond the place intended for the connection of wires referred to the free end or one half of the tag length, whichever is less.

19.2.4 The dross and burned flux shall be skimmed from the surface of the molten solder. The molten solder shall then be stirred with a clean, stainless steel paddle to ensure that the solder bath is at a uniform temperature of 260 ± 10°C. The surface of the molten solder shall be skimmed again just prior to the immersion of the terminations. The fluxed terminations shall then be mechanically immersed at a rate of 20 to 30 mm per second into the solder bath.

19.2.5 The terminations shall be allowed to remain in the solder bath for 4·5 to 5·5 seconds at the end of which period they shall be withdrawn mechanically from the solder bath at a rate of 20 to 30 mm per second.

19.2.6 The residual flux shall be removed by dipping the terminations in clean isopropyl alcohol. If necessary, a soft cloth moistened with clean 91 percent isopropyl alcohol shall be used to remove all remaining flux.

19.2.7 The terminations shall then be examined under magnification. A minimum of 95 percent of the solderable surface of the terminations shall be seen to be covered by continuous coating of solder and that the pin holes or voids are not concentrated in one area.

19.3 Requirement — There shall be no visible evidence of damage due to heating when viewed under magnification of 10 X.

19.3.1 The measurements to be made after the test shall be specified in relevant detail specification.

20. TEMPERATURE CYCLING

20.1 Purpose — The purpose of this test is to determine the resistance of a device to exposure to extremes of high and low temperatures and to the effect of alternate exposures to these extremes.

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*Basic environmental testing procedures for electronic and electrical items : Part XVIII Solderability test, Sec 1 Solderability of wire and tag terminations.

20.2 Procedure

20.2.1 The components shall be introduced into the cold chamber while it is maintained at the appropriate temperature (dry cold) severity, as specified in detailed specification.

20.2.2 The components shall be exposed to these conditions for a period of 10 minutes.

20.2.3 The components shall then be removed from the cold chamber and exposed to atmospheric conditions for testing for a period not exceeding five minutes.

20.2.4 The components shall then be introduced into the dry heat chamber which is maintained at the appropriate temperature (dry heat) severity, as specified in detailed specification.

20.2.5 The components shall be exposed to the conditions for a period of 10 minutes.

20.2.6 The components shall then be removed from the dry heat chamber and exposed to atmospheric conditions for testing for a period not exceeding five minutes.

20.2.7 The above procedure under **20.2.1** to **20.2.6** shall constitute one cycle. The components shall be subjected to a total of five such cycles.

20.3 Requirements — There shall be no evidence of physical damage.

20.3.1 The following details shall be specified in the relevant details specification:

a) Special mounting, if applicable;

b) Test temperatures, minimum and maximum — Unless otherwise specified, the minimum temperature shall be $-65\,^{+0}_{-5}$ °C and maximum $+150\,^{+5}_{-0}$ °C;

c) Number of cycles — unless otherwise specified, this test shall be conducted for a minimum of 10 cycles; and

d) Measurements to be made after the test.

21. THERMAL CHARACTERISTICS

21.1 Purpose — The purpose of this test is to determine the case or junction temperature (T_C or T_J), heat sink temperature (T_S), thermal response time (T_{CX}), or the thermal resistance θ_{J-A} of micro circuit devices.

21.1.1 *Definitions* — The following definitions and symbols shall apply for the purpose of this test:

a) Thermal resistance, junction to ambient θ_{J-A} in degrees Celcius per watt.

b) Thermal resistance, junction to case θ_{J-C} in degree Celcius per watt.

c) Junction temperature (T_J), in degree Celcius.

d) Case temperature (T_C), in degree Celcius.

e) Heat sink temperature (T_S), in degrees celcius. For devices which, in their normal application, are intimately connected (by pressure contact, adhesive, soldering, welding or other means) to a heat sink, the heat sink temperature as measured at a point on the heat sink nearest to the device will be taken as the effective heat sink temperature (T_S), and this temperature may also be used as the equivalent case temperature (T_C).

f) Ambient temperature (T_A), in degrees Celcius. The ambient temperature will be monitored by three thermal probes and an average of the three used. The ambient thermal probes will be positioned in close proximity to the component being measured and when in an air environment, they should have a low absorptivity to reduce radiation effects. During ambient temperature recording, the ambient medium will have velocities not exceeding those set up by natural means except in specific forced-air ventilation tests.

g) Thermal time constant (T_{CX}), is the time required for the junction temperature within a device to reach 63·2 percent of the final value of junction temperature change caused by application of a step function in power dissipation when the device case or ambient temperature, as specified, is held constant.

h) Thermal response time (T_R), is the time required for the junction temperature within a device to reach 90 percent of the final value of junction temperature change caused by application of a step function in power dissipation when the device case or ambient temperature, as specified, is held constant.

21.1.2 *Apparatus* — The apparatus required for these tests shall include the following as applicable to the specified test condition letter:

a) Thermocouple material shall be copper/constantan for the temperature range — 190 to 350°C. The junction thermocouple shall be welded together to form a bead rather than soldered or twisted. The accuracy of the thermocouple shall be ± 1·0°C where devices are exposed to convection cooling and ± 2·0°C for forced air ventilation.

b) Infrared microradiometer capable of measuring radiation in the range 2 to 10 μm range and having sufficient heat resolution to detect radiation emitted from an area 38 by 39 μm;

c) Controlled temperature chamber capable of maintaining the specified ambient temperature with indicator or a controlled temperature heat sink capable of maintaining the specified heat sink temperature, and

d) Suitable electrical equipment as required to provide controlled levels of conditioning power and to make the specified measurements.

21.2 Procedure

21.2.1 *Test Condition A—Case Temperature* (T_c)

21.2.1.1 *Hex-base mounted devices* — A small hole, just large enough to insert the thermocouple, shall be drilled approximately 0·8 mm deep into the flat of the case hex at a point chosen by the manufacturer. The edge of the hole should then be pierced with a small centre punch to force a rigid mechanical contact with the welded bead of the thermocouple. If forced-air ventilation is used, the thermocouple shall be mounted away from the air stream and the thermocouple leads close to the junction shall be shielded.

21.2.1.2 *Other devices* — Other types of devices will be mounted by their normal mounting means in their normal mounting position. A thermocouple shall be attached as near as is possible to the centre of the bottom of the device case directly under the chip or substrate. As an alternative, a microradiometer scan may be made at the same point on the bottom of the case, in which case the surface emissivity must be known and controlled. The test specimen shall be operated at the specified power level and the following data recorded:

a) Specimen case temperature (T_c) or heat sink temperature (T_S) where applicable;

b) Ambient temperature (T_A); and

c) Power dissipation (P_D).

The specimen shall be considered stabilized when the measured case temperature does not change by more than 2°C per hour.

21.2.2 *Test Condition B—Junction Temperature* (T_j) — The junction temperature of semiconductor devices cannot be measured directly except by the infrared microradiometer method. With the specimen in its normal mounting position and specified power applied, the radiometer shall be focussed on the junction to be measured. The top cap or lid shall be removed or opened sufficiently to permit observation of the active chip or substrate. The opened area shall be covered with a material exhibiting high transmissibility in the IR range to eliminate convection current. The surface emissivity must be known and controlled. The following data shall be recorded after the device is stabilized:

a) Case temperature (T_C);
b) Junction temperature (T_J);
c) Power dissipated (P_D);
d) Ambient temperature (T_A);
e) Heat sink temperature (T_S), and
f) Ambient fluid.

The specimen shall be considered stabilized when measured temperature does not change by more than 2°C per hour.

21.2.3 *Test Condition C—Thermal resistance* θ_{J-C}—The thermal resistance of a microcircuit device may be calculated from a knowledge of the case and junction temperature and the power dissipation in the device being measured or may be determined by measurement of a temperature sensitive parameter of semiconductor junction(s) within the device. The latter method involves variation of ambient temperature and power dissipation within the device and avoids the necessity of performing a direct measurement of device junction temperature. The thermal resistance of a microcircuit device may be determined by performing any of the procedures described in **21.2.3.1** to **21.2.3.6**. Test Condition C_1 provides for the calculation of θ_{J-C} from case and junction temperatures and power dissipation. Test Condition C_2 describes a diode (two terminal) measurement to determine θ_{J-C}. Test Condition C_3 through C_6 describe transistor (three terminal) measurement to determine R_{th}. Unless otherwise specified, where more than one diode junction or transistor in the device is available through the external leads (or by probing, for unsealed devices), that available junction or transistor which dissipates the greatest amount of power in the particular device shall be selected for θ_{J-C} measurements. Where thermal resistance from junction to ambient is being measured, θ_{J-A} should be substituted for θ_{J-C} condition C procedures.

21.2.3.1 *Test Condition* C_1 — Where the junction temperature (T_J), case temperature (T_C), and power dissipation (P_D) for the same junction and under the same conditions are specified or have been measured using test conditions A and B of this method, the thermal resistance θ_{J-C} may be determined as follows:

$$\theta_{J-C} = \frac{T_J - T_C}{P_D}$$

where

P_D = Power dissipation, in watts

21.2.3.2 *Test Condition* C_2 (*Diodes*) — This test shall be done in accordance with Fig. 4A. S_1 is closed for a much longer interval (heat) than it is opened (Measurement). The measurement interval should be short compared to the thermal response time of the device being measured. The constant measurement current is a small current (of the order of a few milliamperes) and so selected that the magnitude of V_{F1} changes appropriately with the device material (for silicon, approximately 2mV/°C) and junction temperature. The heating current source should be adjustable.

The measurement is made in the following manner. The case, ambient or other reference point is elevated to a high temperature, T_2, not exceeding the maximum junction temperature and the forward voltage drop V_{F1} read with the heating source supplying no current (that is, the forward voltage V_{F1} is to be read at the start of the measurement interval). An oscilloscope makes a convenient detector. At T_2 there will be a small power dissipated in the device due to the measurement current source. The reference is then reduced to a lower temperature T_1, and Power P_D is applied to heat the device by increasing the current from the constant current source until the same value of V_{F1} is read as was read above. However, if P_D is calculated as the heating power contributed by the heating current source, only the following equation gives θ_{J-C} accurately.

$$\theta_{J-C} = \frac{T_2 - T_1}{P_D}$$

where

$$P_D = V_{F1}\, I_{F1}$$

21.2.3.3 *Test Condition* C_3 — (Forward voltage drop) (Emitter base). This test shall be done in accordance with Fig. 4B. S_1 is closed for a much larger interval (heat) than it is open (measurement). The measurement interval should be short compared to the thermal response time of the device being measured. The constant measurement current is a small current (of the order of a few milliamperes) so selected that the magnitude of V_{EB} changes approximately 2mV/°C of junction temperature change. The heating current source should be adjustable. The procedure is recommended for devices having relatively short thermal response times.

The measurement is made in the following manner. The case, ambient or other reference point is elevated to a high temperature, T_2, not exceeding the maximum junction temperature, and the emitter to base voltage V_{EB} read with the constant current source supplying no current. V_{EB} should be read at the start of the measurement interval. An oscilloscope makes a convenient detector. At T_2 there will be small power dissipated in the device due to the measurement current source. The reference temperature is then reduced to a lower temperature T_1, and power P_D is applied to heat the device, by increasing the current from the constant current source, until the same value of V_{EB} is read as was read above. However, if P_D is calculated as the heating power contributed by the heating current source, only the following equation gives θ_{J-C} accurately.

$$\theta_{J-C} = \frac{T_2 - T_1}{P_D}$$

where

$P_D = (n)(I_C V_{CB} + I_E V_{EB})$

n = duty cycle = $\frac{t_{on}}{t_{total}}$

21.2.3.4 *Test Condition C_4 (Forward voltage drop)* — This test shall be done in accordance with Fig. 4C. The measurement technique assumes that the forward emitter voltage drop varies with temperature. It further assumes that during the course of measurement, the variation in forward emitter voltage drop varies monotonically due to the variation with collector voltage. These assumptions must be maintained to achieve valid and reproducible results.

The measurement is made in the following manner. The case, ambient or other reference point is elevated to a high temperature T_2, not exceeding the maximum junction temperature. Current I_C is set to a value and a voltage V_2 applied to the collector base diode. The value of V_2 applied shall be low, yet high enough, so that the device is operating in a normal manner, V_{EB} is read under these conditions. The reference temperature is reduced to a lower temperature T_1 and V_{CC} varied until the same value of V_{EB} is read as was read above. The thermal resistance is then

$$\theta_{J-C} = \frac{T_2 - T_1}{I_C (V_1 - V_2)}$$

where

V_1 is the collector-base voltage V_{CB} applied at temperature T_1 and V_2 is V_{CB} at temperature T_2.

21.2.3.5 *Test Condition C_5 (Forward voltage drop, Collector to Base)* — This test shall be done in accordance with Fig. 4D. Switches S_1 and S_2 are ganged switches and are so arranged that S_2 opens very shortly after S_1 opens and such that the delay between openings is much shorter than the thermal response time of the device being measured. S_1 and S_2 should be closed (heat interval) for a much larger time than they are open

(measurement interval) and the measurement interval should be short (less than 1/10 T_R) compared to the thermal response time of the device being measured. This procedure is recommended for devices having relatively long thermal response times.

The measurement is made in the following manner. The case, ambient or other reference point is elevated to a high temperature T_2, not exceeding the maximum junction temperature, and the collector base voltage, V_{CB} is read. This reading is made at the beginning of the measurement interval. An oscilloscope makes a convenient detector. The reference temperature than reduced to a lower temperature T_1. The heating power, P_D is adjusted by adjusting the heating current source in the emitter circuit until the same value of V_{CB} is read as was read above. The θ_{J-C} is calculated from the equation.

$$\theta_{J-C} = \frac{T_2 - T_1}{P_D}$$

where

$$P_D = (n) (I_C V_{CB} + I_E V_{EB})$$

$$n = \text{duty cycle} = \frac{(t_{on})}{(t_{total})}$$

21.2.3.6 *Test Condition C_6 (dc current gain) (continuous)* — This test shall be done in accordance with Fig. 4E. The measurement technique assumes that the current gain varies with temperature. The rate of change is important. It further assumes that during the course of measurement the variation in current gain varies monotonically due to temperature variation and is much greater than that due to the variation with collector voltage. These assumptions must be maintained to achieve valid and reproducible results.

The measurement is made in the following manner. The case, ambient or other reference point is elevated to a high temperature T_2, not exceeding the maximum junction temperature. Current I_C is set to a value and a voltage applied to the collecter base diode V_2. The value of V_2 applied shall be low, yet high enough so that the device is operating in a normal manner. I_B is read under these conditions. The reference temperature is then reduced to a lower temperature T_1 and V_{CC} is varied until the same value of I_C is read as was read above. The thermal resistance is:

$$\theta_{J-C} = \frac{T_2 - T_1}{I_C (V_1 - V_2)}$$

where

V_1 is the collector voltage V_{CB} applied at temperature T_1, and

V_2 is V_{CB} at temperature T_2.

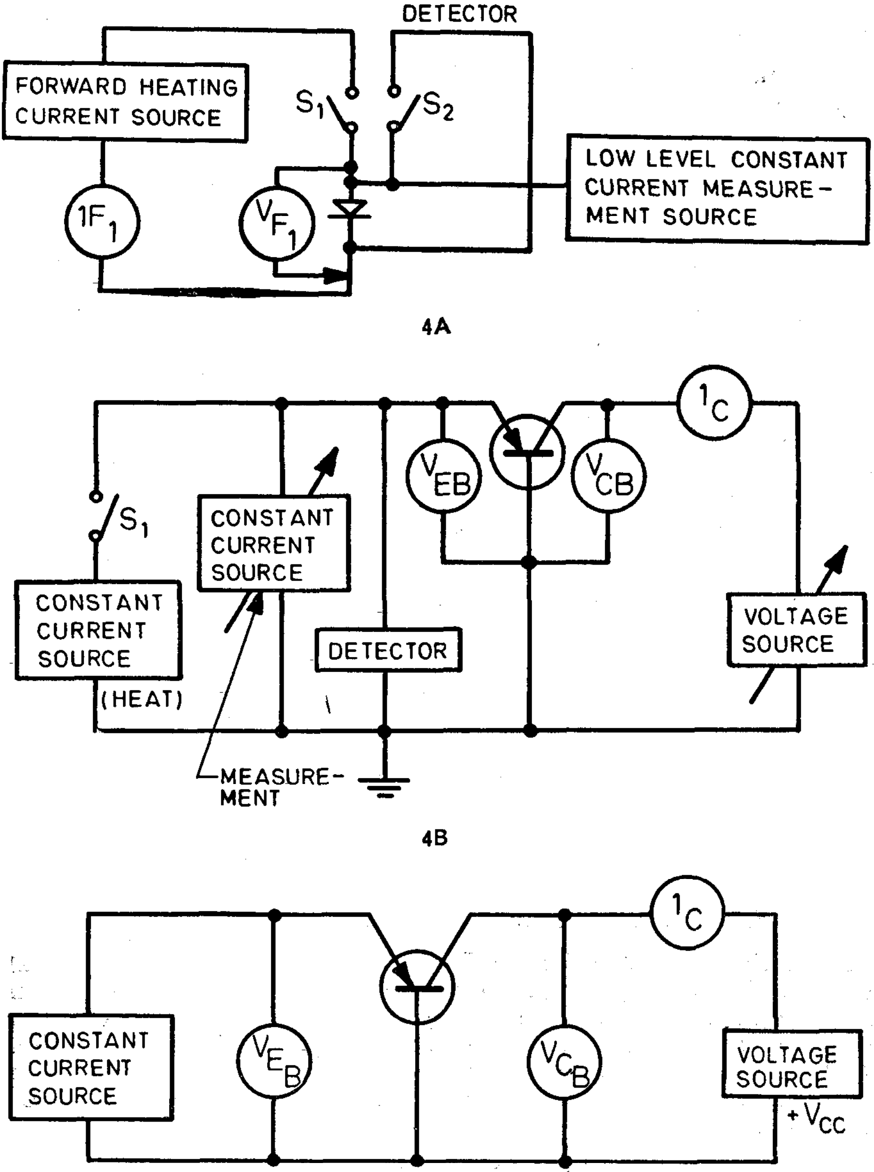
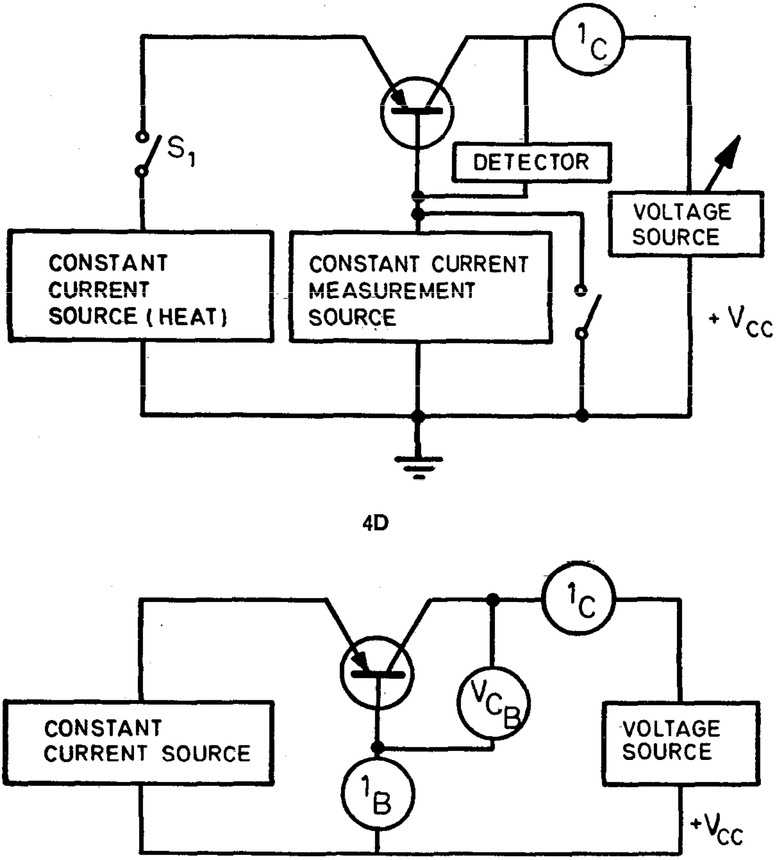


FIG. 4 MEASUREMENT OF THERMAL CHARACTERISTICS — *Contd*



4D

4E

FIG. 4 MEASUREMENT OF THERMAL CHARACTERISTICS

21.2.4 *Test Condition D-Junction Temperature* (T_j) — Where the internal thermal resistance θ_{J-C} of a micro circuit device is specified or has been measured in accordance with Test Conditions C_2 through C_5 of this method and where the case temperature (T_C) and power dissipation (P_D) are specified or measured for the same junction in the devices and under the same conditions, the junction temperature (T_j) may be determined as follows:

$$T_j = T_C + \theta_{J-C} (P_D)$$

where

P_D = Power dissipation, watts.

21.2.5 *Test Condition E-Thermal Time Constant and Response Time* — When a step function of power dissipation is applied to a semiconductor device, the junction temperature does not rise as a step function, but rather as a complex exponential curve. The change in junction temperature as a function of time resulting from the sudden application, increase or removal of power dissipation in the junction shall be observed using an IR radiometer with a response time of less than 1 millisecond or electrical equipment with response time of less than 1 millisecond and sufficient sensitivity to read a precalibrated temperature sensitive electrical parameter of the junction. During this test, the device case or ambient temperature, as specified, shall be held constant, the step function of power dissipation shall be applied and the wave form of the junction temperature response versus time shall be recorded from the time of application to the time when the junction temperature reaches a stable value as evidenced by a temperature change of less than 2°C per hour.

21.2.5.1 *Thermal time constant* — The value of thermal time constant (T_{CX}) for the device under specified conditions shall be determined as the time required in millisecond after application of the step function in power for the junction temperature to reach 63·2 percent of the final stable value.

21.2.5.2 *Thermal response time* — The value of thermal response time (T_R) for the device under specified conditions shall be determined as the time required in milliseconds after application of the step function in power for the junction temperature to reach 90 percent of the final stable value.

21.3 Summary — The following details must be specified in the applicable procurement document:

a) Test condition letter;

b) Mounting arrangement for device under test;

c) Test temperature(s) (case, ambient, sink or junction temperatures), as applicable;

d) Test voltage, test currents and power dissipation where applicable including duty cycle for pulse test, and

e) θ_{J-C} or θ_{J-C} T_{CX} or T_R as applicable, for test to determine compliance with specified values of these parameters.

22. THERMAL SHOCK

22.1 Purpose — The purpose of this test is to determine the resistance of the device to sudden exposure to extreme changes in temperature.

22.2 Procedure

22.2.1 The components shall be preconditioned by immersing them in a hot bath which is maintained as the specified temperature for a minimum of 15 seconds.

22.2.2 Immediately at the conclusion of the preconditioning period, the components shall be transferred to the cold bath which is maintained at the specified temperature and shall remain immersed in the cold bath for a minimum of five minutes.

22.2.3 The components shall then be transferred to the hot bath which is maintained at the specified temperature and shall remain immersed in the hot bath for a minimum of five minutes.

22.2.4 The transfer time from one bath to other shall not be more than 10 seconds.

22.2.5 The above procedure under **22.2.2** and **22.2.4** shall constitute one cycle. The components shall be subjected to a total of 15 such cycles, unless otherwise specified.

22.3 Requirements — At the conclusion of the specified number of the cycles the device shall be subjected to external visual inspection at a magnification between 10X and 20X and there shall be no evidence of physical damage to case, leads or seals.

THERMAL SHOCK TEST CONDITIONS

Test Condition	1 Temp°C	2 Temp°C	3 Temp°C	4 Temp°C	5 Temp°C	6 Temp°C
Step 1	100^{+5}_{-0}	125^{+5}_{-0}	150^{+5}_{-0}	200^{+5}_{-0}	150^{+5}_{-0}	200^{+5}_{-0}
Step 2	0^{+0}_{-5}	-55^{+0}_{-5}	-65^{+0}_{-5}	-65^{+0}_{-5}	-195^{+5}_{-5}	-195^{+5}_{-5}

SUGGESTED THERMAL SHOCK FLUIDS

Test Condition	1 Fluid	2 Fluid	3 Fluid	4 Fluid	5 Fluid	6 Fluid
Step 1	Water*	FC 40 or FC 70	FC 40 or FC 70	UCON 100 or FC 70	FC 40 or FC 70	UCON 100 or FC 70
Step 2	Water*	FC 77	FC 77	FC 77	Liquid nitrogen	Liquid nitrogen

NOTE — Ethylene glycol shall not be used as a thermal shock test fluid.

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*Water is indicated as an acceptable fluid for this temperature range; its suitability chemically shall be established prior to use.

22.3.1 The following details shall be specified in the relevant detail specification:

a) Unless otherwise specified test condition 1 shall be used;

b) Number of cycles, if other than 15,

c) Visual examination (X 20 magnification) to be carried out; and

d) Measurements to be made after the test.

23. VIBRATION

23.1 Purpose — The purpose of this test is to determine the effect on the devices, of vibration in the frequency range specified.

23.2 Procedure

23.2.1 *Test Condition A—Vibration Fatigue* — The device shall be rigidly fastened on the vibration platform and the leads or cables adequately secured. Lead mounted devices shall be mounted by their leads in the normal mounting configuration. The device shall be vibrated with a constant amplitude simple harmonic motion having a peak acceleration (20 g, 50 g or 70 g) as specified in the relevant detailed specification. The frequency range shall be 50 ± 20 Hz. The vibration shall be applied for 32 ± 8 hours minimum, in each of the orientations X, Y and Z for a total of 96 hours, minimum. The procedure shall consist of the following sequence of testing.

23.2.1.1 *Initial resonance search* — The component shall be vibrated over the whole range of specified frequencies as the specified amplitude. It is checked functionally and examined for any resonances and malfunctioning. These vibration characteristics as well as the frequencies and amplitudes at which they occur are noted. The initial resonance search is carried out for information only.

23.2.1.2 *Endurance testing and predetermined frequencies* — Endurance testing at one or more specified frequencies (or narrow band of frequencies) is carried out at specified amplitude for specified durations.

23.2.1.3 *Final resonance search* — After the endurance testing, the component is retested functionally and re-examined for vibration characteristics as in the initial resonance search. The frequencies for each effect, determined in the initial and later in the final resonance searches are compared. The final resonance search is carried out for information only.

23.2.2 *Test Condition B—Vibration Variable Frequency* — The device shall be rigidly fastened on the vibration platform and the leads or cables adequately secured. Lead mounted devices shall be mounted by their leads in the normal mounting configuration. The device shall be vibrated with simple harmonic motion having a peak acceleration of 20 g (unless otherwise specified in the relevant detail specification) or 1·5 mm amplitude (total excursion), whichever is less. The vibration frequency shall be varied approximately logarithmically between 20 and 2 000 Hz. The entire frequency range of 20 to 2 000 Hz and return shall be traversed in not less than four minutes. This cycle shall be performed four times in each of the orientations X, Y and Z (total 12 times), so that the motion shall be applied, for a total period of approximately 48 minutes minimum, procedure shall be as specified above.

23.2.3 *Test Condition C—Vibration Noise* — The device and its leads shall be rigidly fastened on the vibration platform and the leads or cables securely fastened. Lead mounted devices shall be mounted by their leads in the normal mounting configuration. The device shall be vibrated with simple harmonic motion having an amplitude of 1·5 mm double amplitude (total excursion) or a constant peak acceleration of 200 m/s minimum. The vibration frequency shall be varied approximately logarithmically between 20 and 2 000 Hz. The entire frequency range shall be traversed in not less than four minutes for each cycle. This cycle shall be performed once in each of the orientations X, Y and Z (total three times) so that the motion shall be applied for a total period of approximately 12 minutes. The specified voltage and currents shall be applied in the test circuit. The maximum noise output voltage across the specified load resistance during traverse, shall be measured with an error of not more than 3 percent of the rms value of the sine voltage at 2 000 Hz. The characteristic of the meter over a bandwidth of 20 to 2 000 Hz shall be ± 1 dB of the value at 2 000 Hz with an attenuation rate below 20 and above 2 000 Hz of 6 ± 2 dB per octave. The maximum inherent noise in the circuit shall be at least 10 dB below the specified noise output voltage.

23.3 Requirements — There shall be no evidence of damage to package, leads, seals and markings when the device is subjected to external visual examination at a magnification between 10X and 20X.

23.3.1 The following details shall be specified in the relevant detailed specification:

a) Applicable test condition;

b) Acceleration severity;

c) Test voltage and current (*see* **23.2.3**) unless otherwise specified, these shall be the nominal operating voltages and currents;

d) Load resistance (*see* **23.2.3**) unless otherwise specified this shall be the maximum rated operating load;

e) Noise output voltage limit (*see* **23.2.3**); and

f) Measurements to be made after the test.